



U.S. Department of Energy
Energy Efficiency and Renewable Energy

DATA CENTER ENERGY EFFICIENCY TRAINING

Liquid Cooling



<Presenter>



Outline

- What is liquid cooling?
- Energy Benefits
- What are water side economizers
- Combined benefits

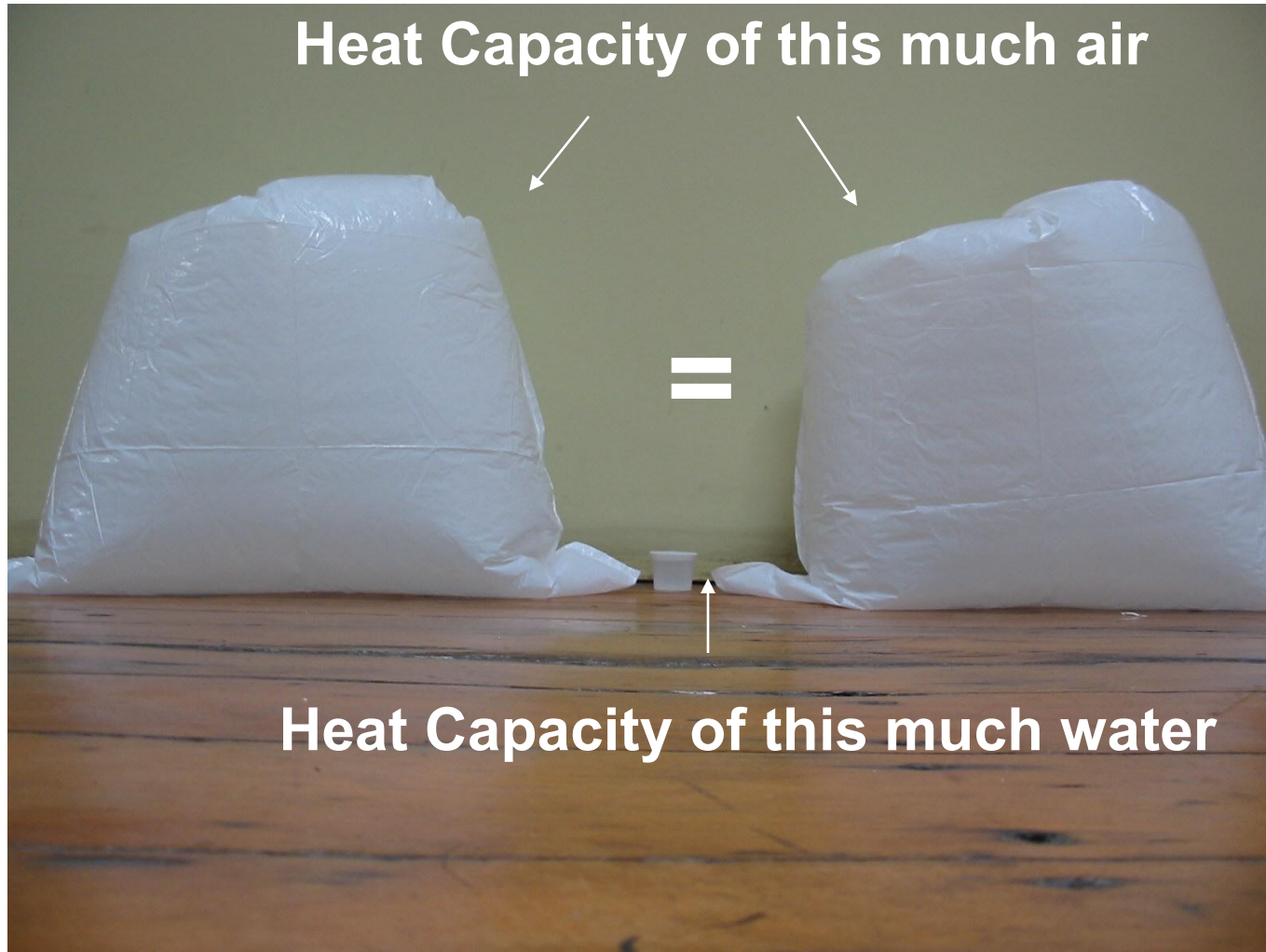


Air cooling issues

- Limitations on the data densities served (~ 200 W/sf)
 - Air delivery limitations
 - Real estate
- Working conditions
 - Hot aisles are approaching OSHA limits
- Costly infrastructure
- High energy costs
- Management over time
- Reliability
 - Loss of power recovery
 - Particulates

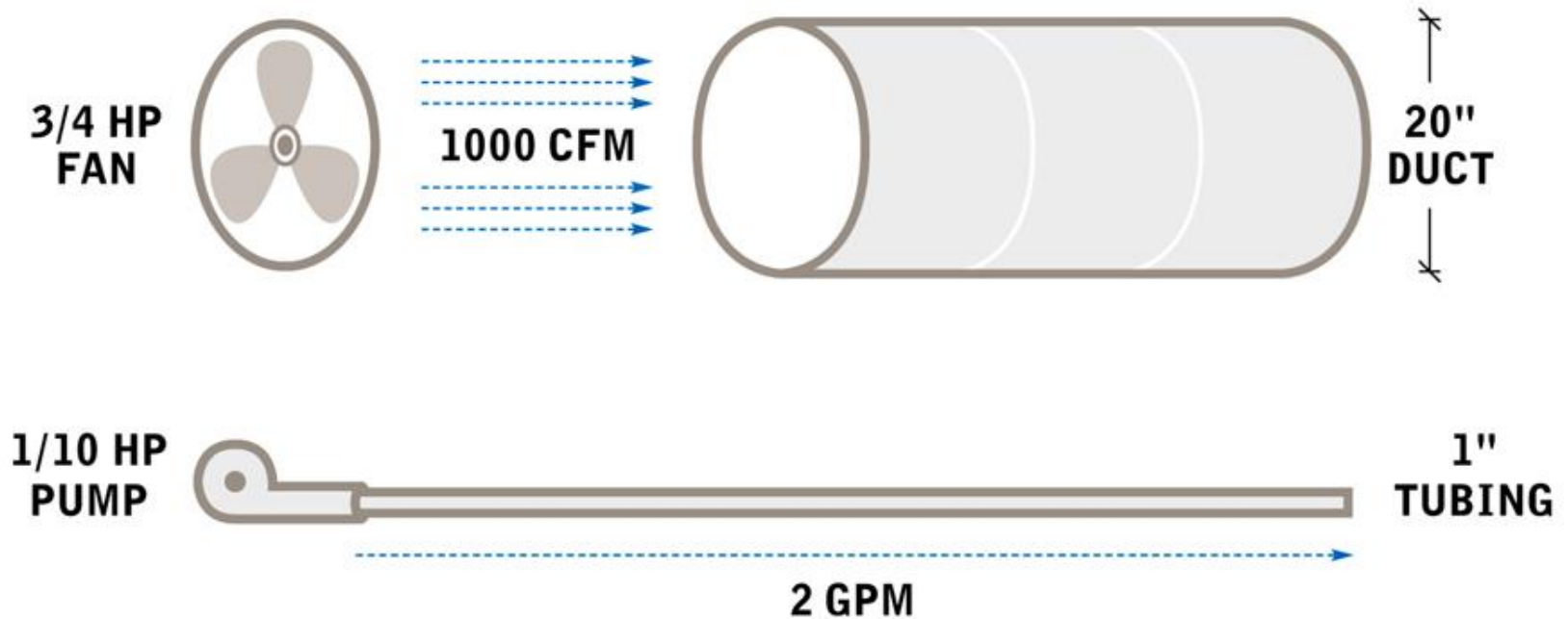


Why Liquid Cooling?



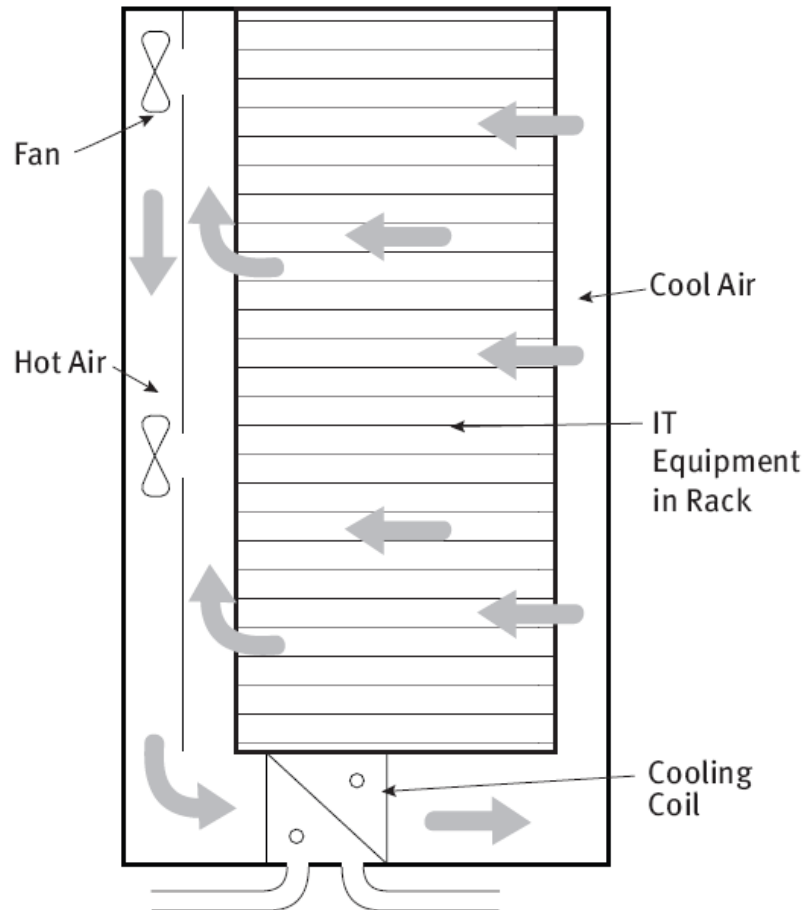


Fans move energy less efficiently





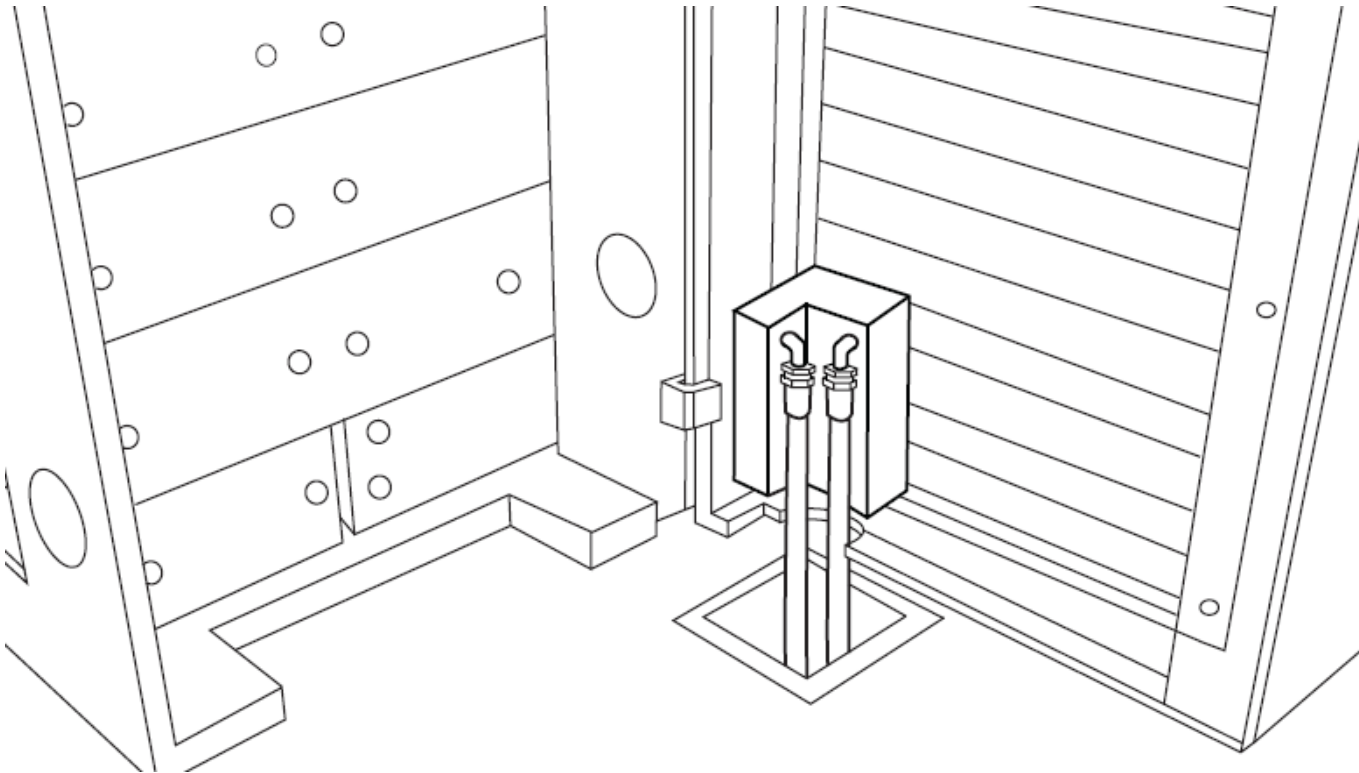
In-rack liquid cooling



Close coupling between
cooling source and server



Rear-door liquid cooling





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Liquid Cooling

Rear door cooling

CoolTherm®

Server cabinet technology with outstanding benefits

... up to 35kW cooling capacity

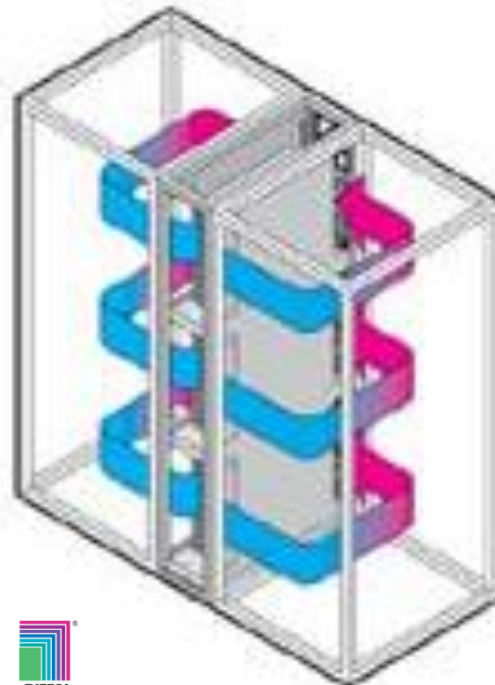
Blade server optimized!

knürr
environments for electronics

The image shows a tall, black server cabinet with its rear door open, revealing internal components. The door has three large circular fans. Below the main text, three smaller server units are shown, labeled 'Blade server optimized!'. The Knürr logo is in the bottom right corner.



In row cooling



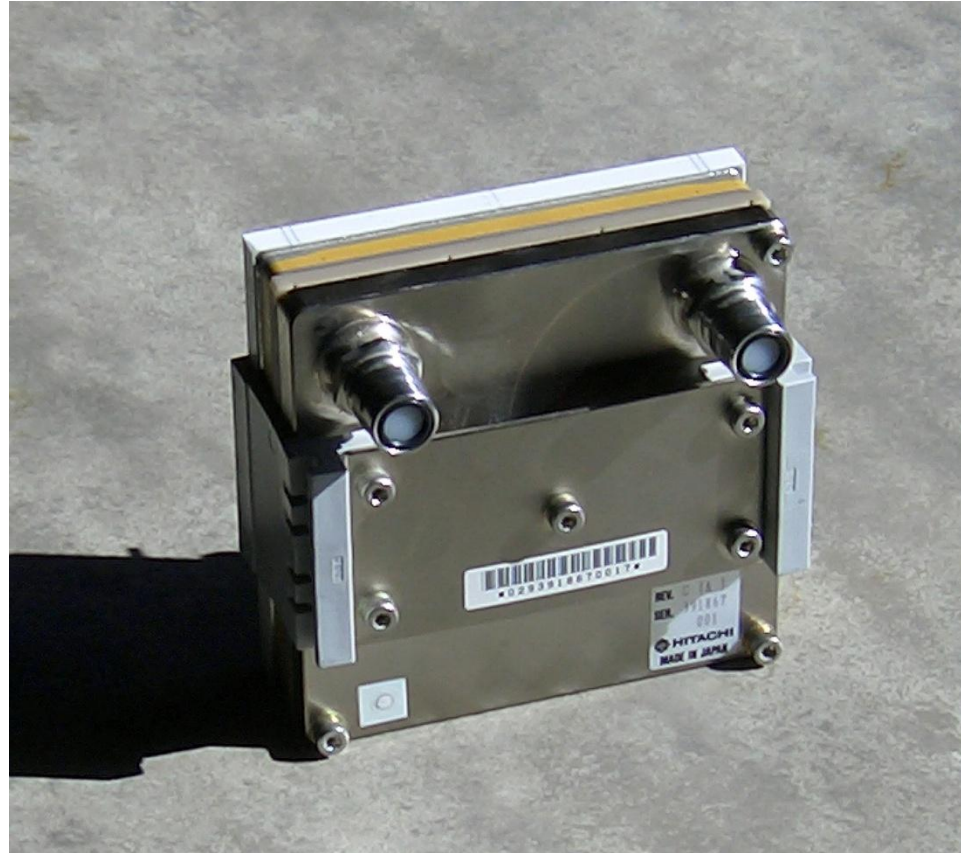


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Liquid Cooling

Yesterday, on board cooling



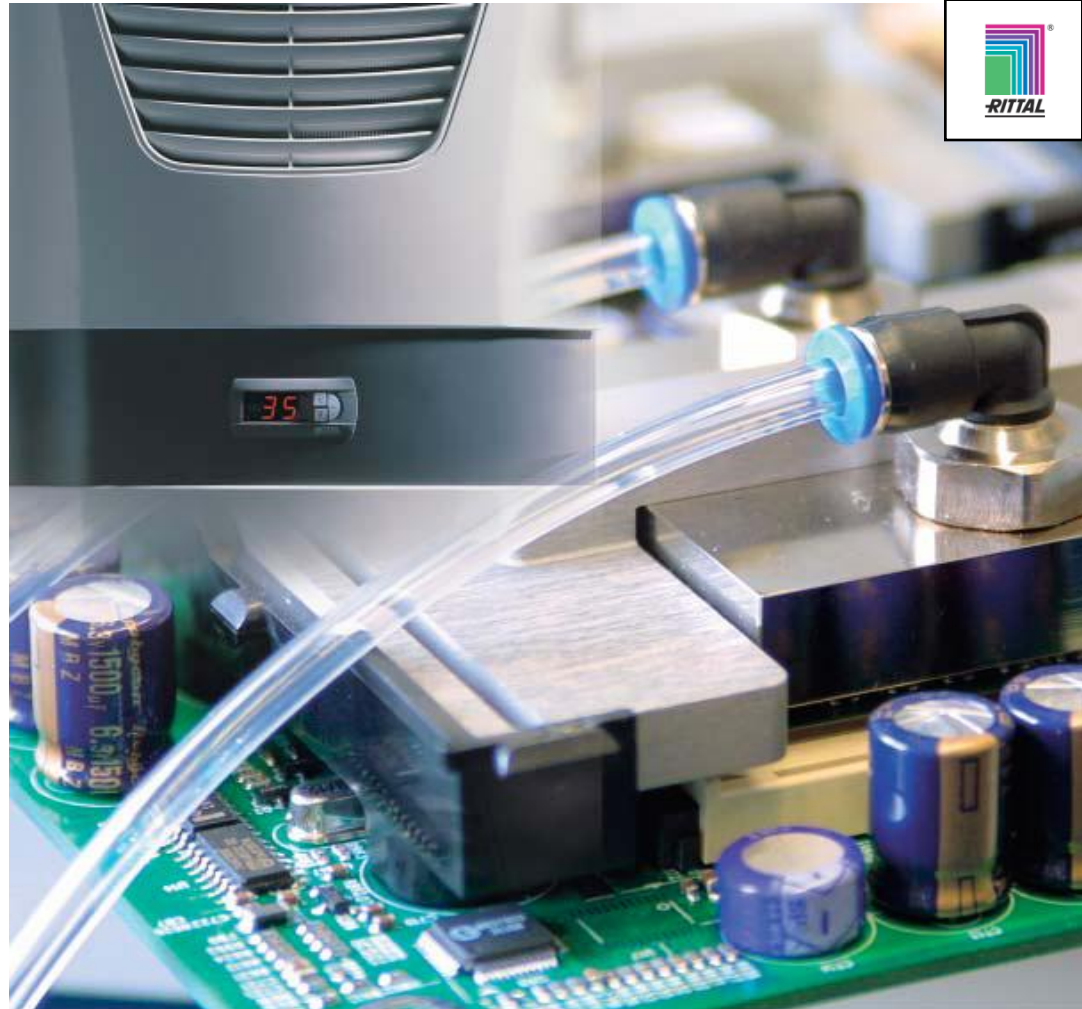


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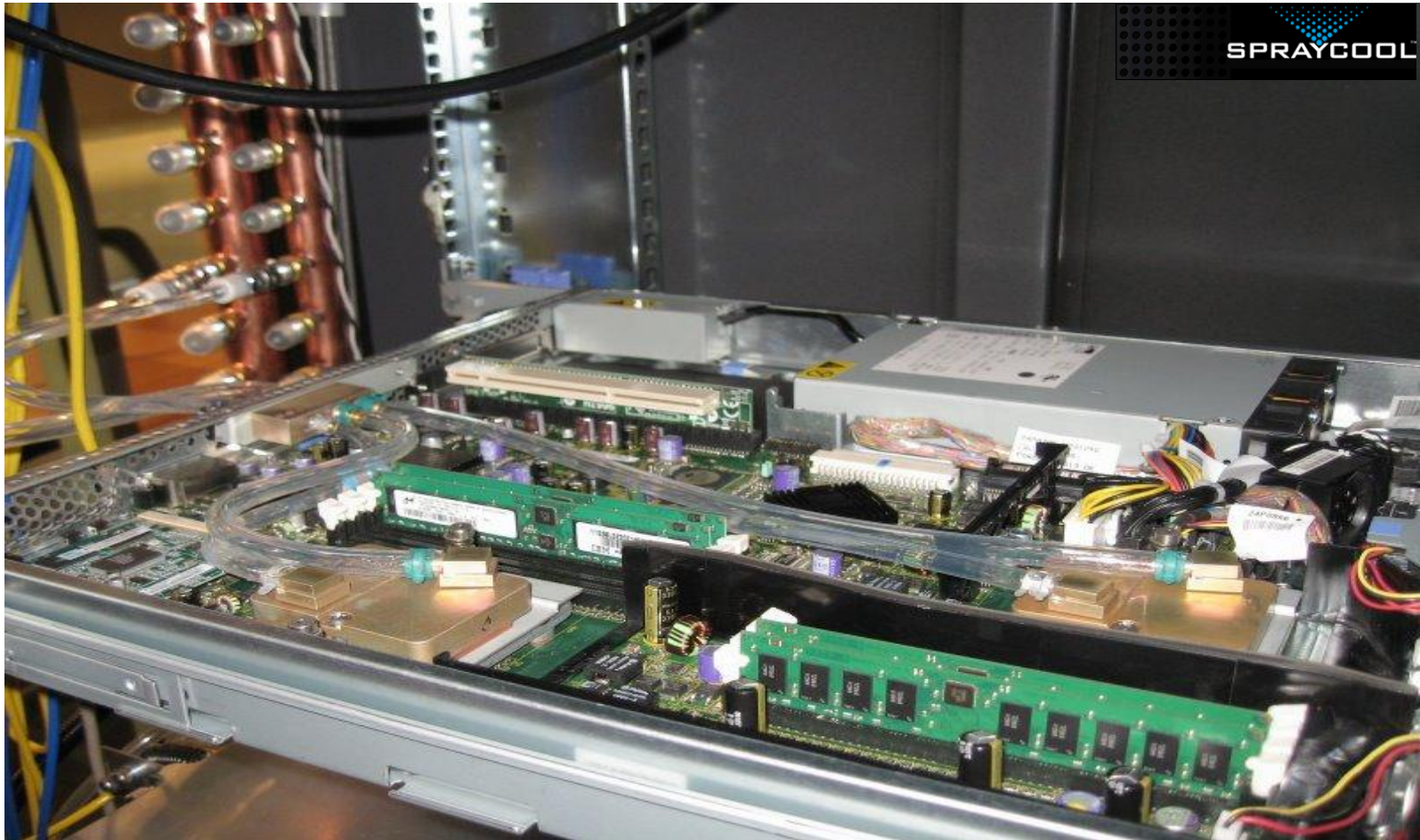
Liquid Cooling

Today, on board cooling





Today, on board cooling





Comparison of conventional cooling to liquid cooling – 1,000 kW data center load

	Cooling Towers and Pumps	Chiller	Chilled Water Pumps	Fans	Other	Total Power (kW)	% SAVINGS
Traditional System - 45 Deg F Chilled Water	70	500	50	150	n/a	770	N/A
Liquid Cooled with Fans in the Rack - 55 Deg F Chilled Water	70	425	50	100	n/a	645	16%
Liquid Cooled without fans in the rack - 55 Deg F Chilled Water	70	425	50	0	n/a	545	29%
Liquid Cooled directly couple with CPU - 70 to 80 deg F Chilled Water	70	0	50	0	Room A/C - 245	365	53%



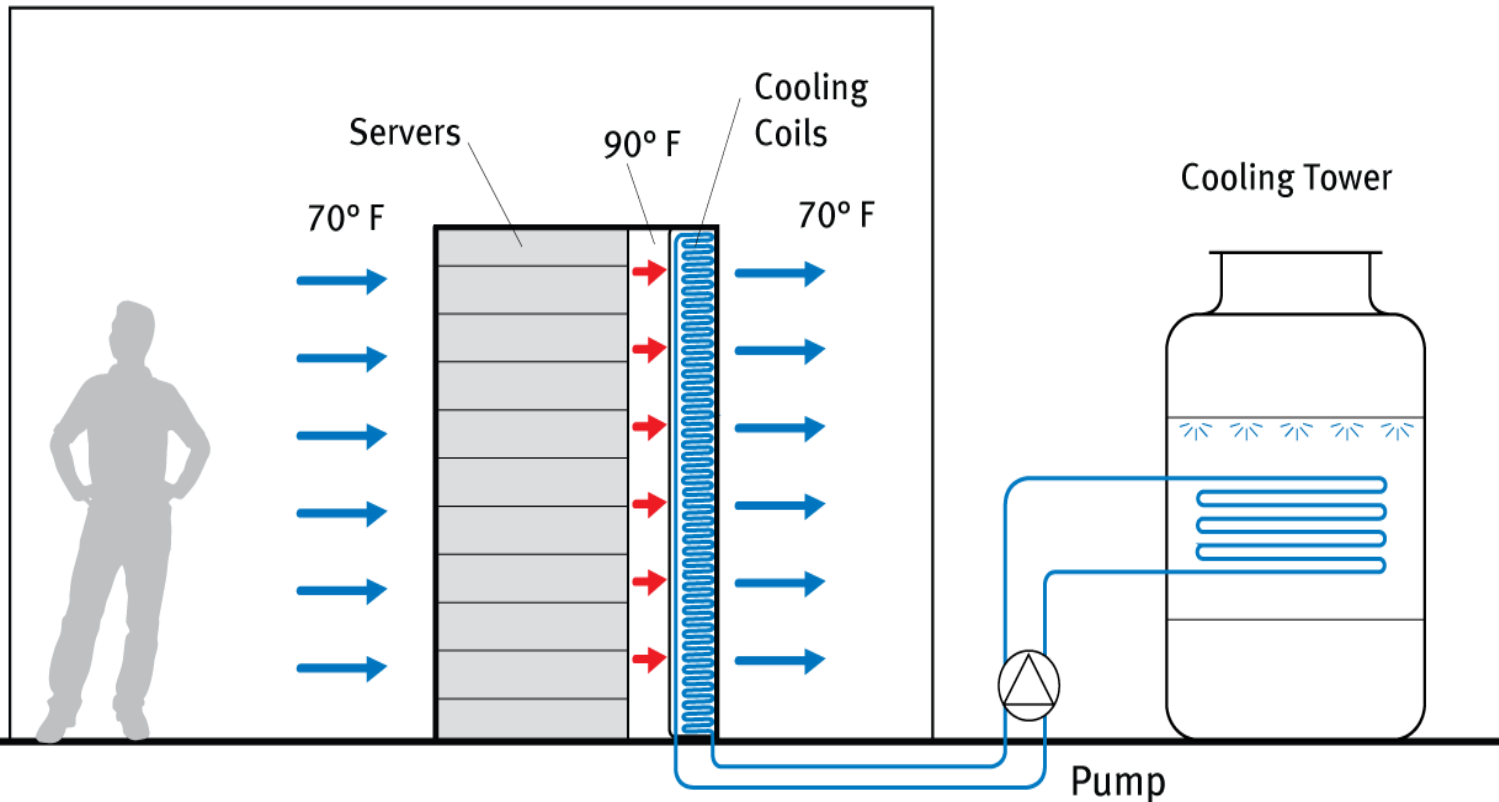
Free Cooling

- Use cooling towers and heat exchanger to produce chilled water
- Turn off chiller





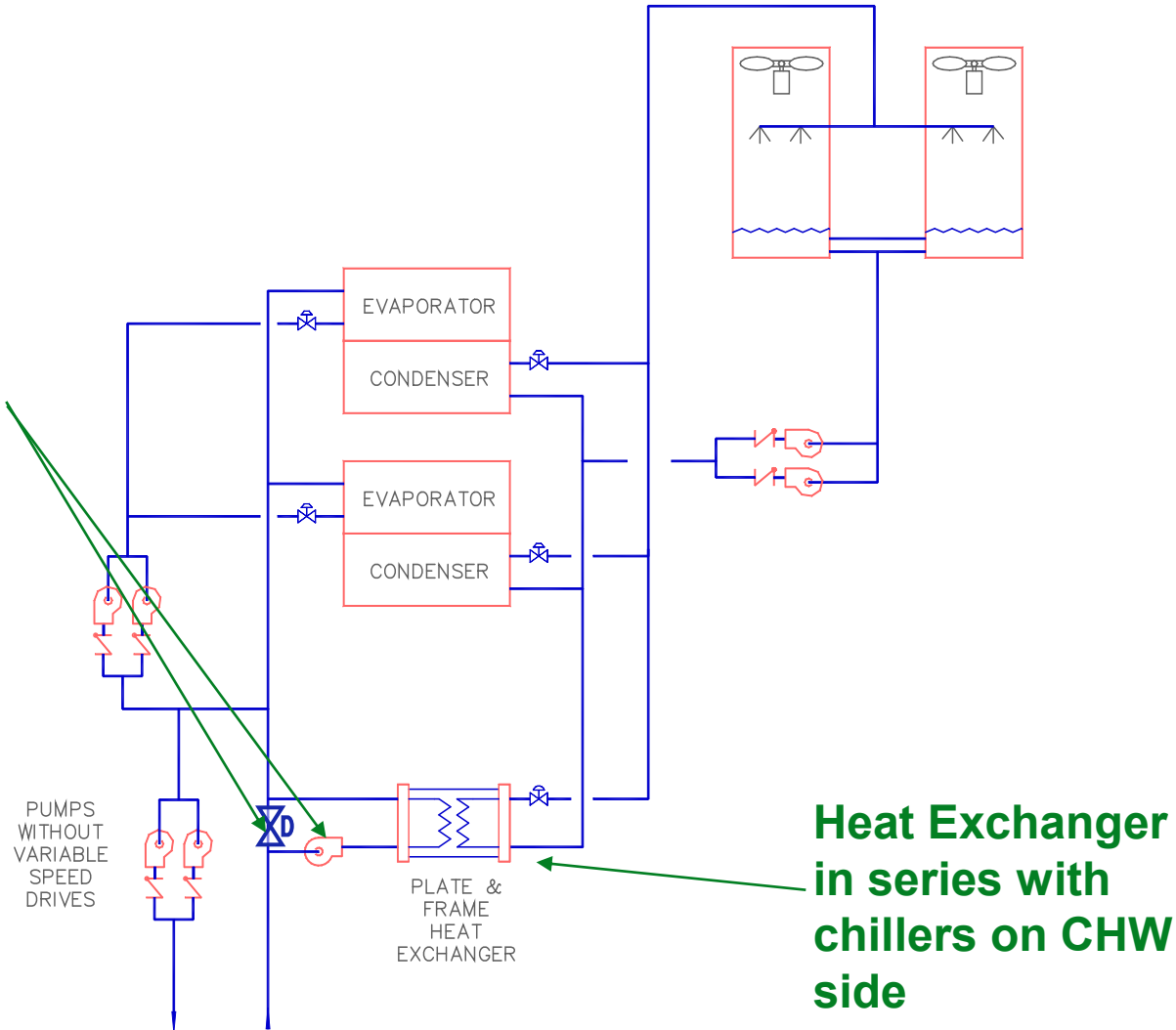
Rear door cooling with condenser water





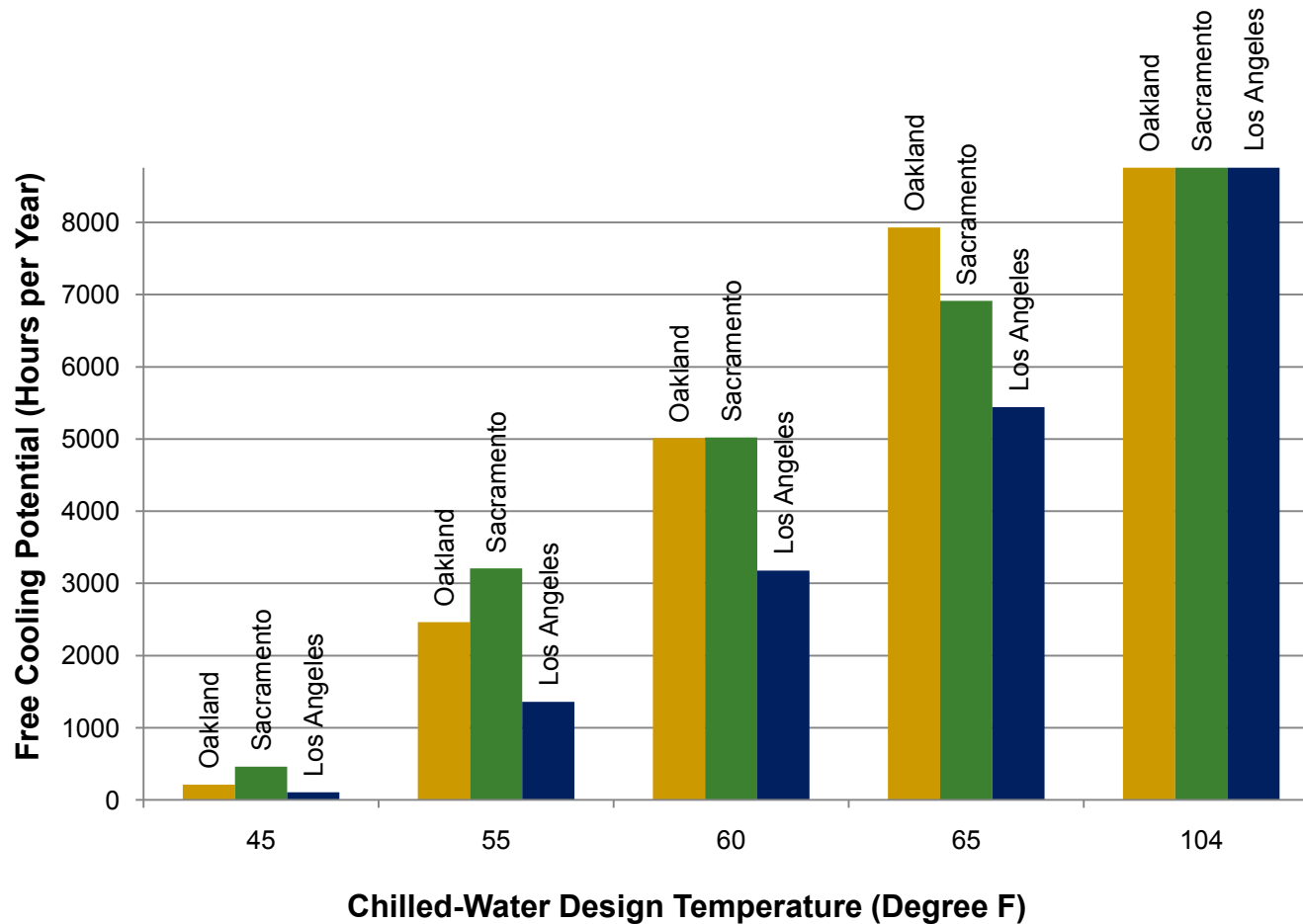
Integrated water-side economizer

**You can use
either a control
valve or pump**





Free Cooling Opportunity





How to compare apples and coconuts

- Sun “Chill Off” is documenting field performance of liquid cooling options (LBNL is involved)
- PG&E Pacific Energy Center Class on June 10th will have update on the “Chill Off” and will compare options by
 - \$/Btuh delivered (contractor’s cost)
 - kWinput/kWcooling
 - Using standard efficiencies for utilities like chilled water and condenser water
 - Major manufacturers will have products on display and presentations
- Register at http://www.pge.com/education_training/classes/energy_efficiency/index.jsp



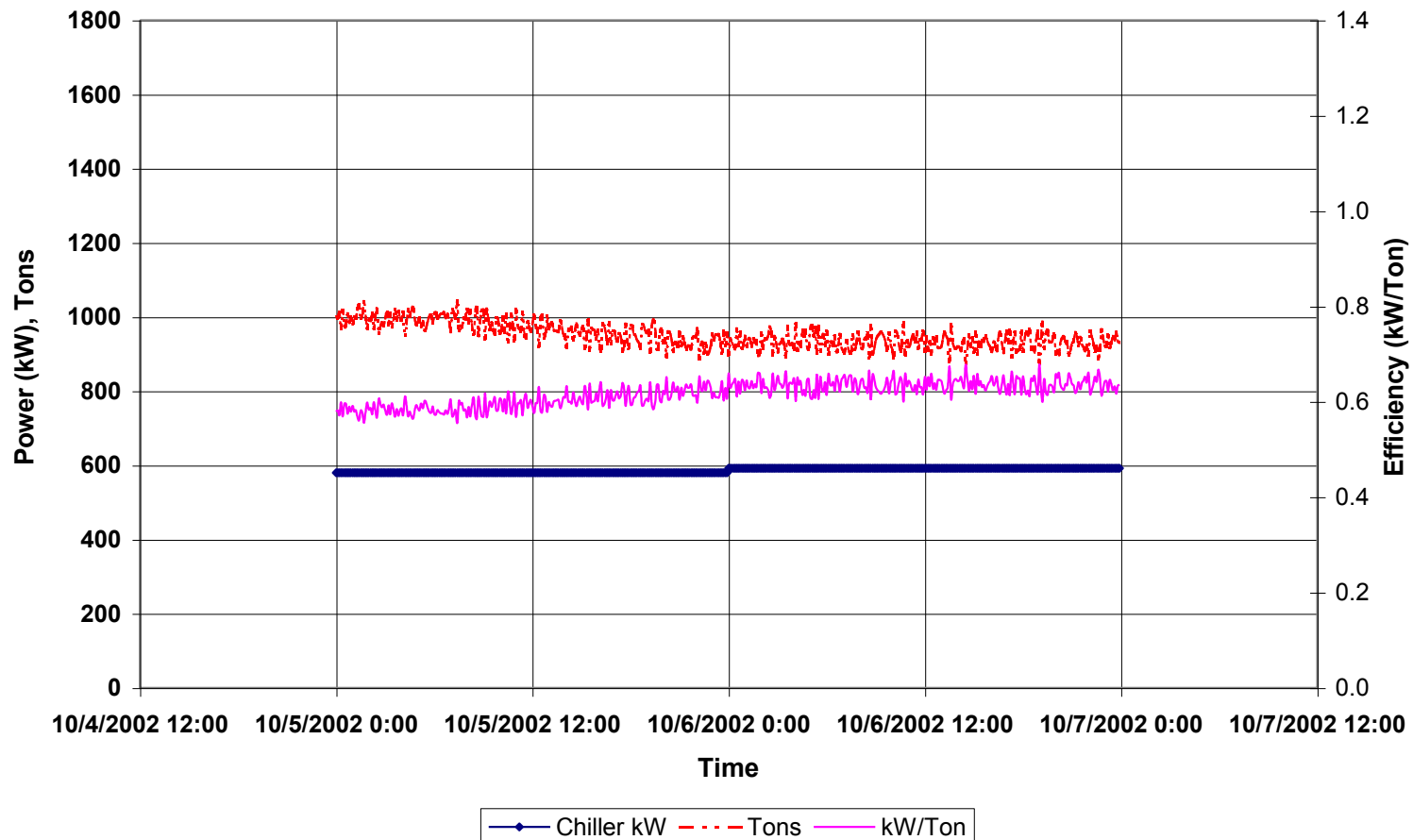
Liquid cooling take aways

- Liquid has greater heat removal capacity
- Pumps are more efficient than fans
- Coupling heat removal to the source eliminates mixing
- Commercially available liquid solutions are available
- The jury is out on the cost effectiveness but the potential for energy savings is large
- Redundancy is a challenge for many liquid cooling technologies
- Water side free cooling provides cooling with reduced chiller operation for much of the year in California



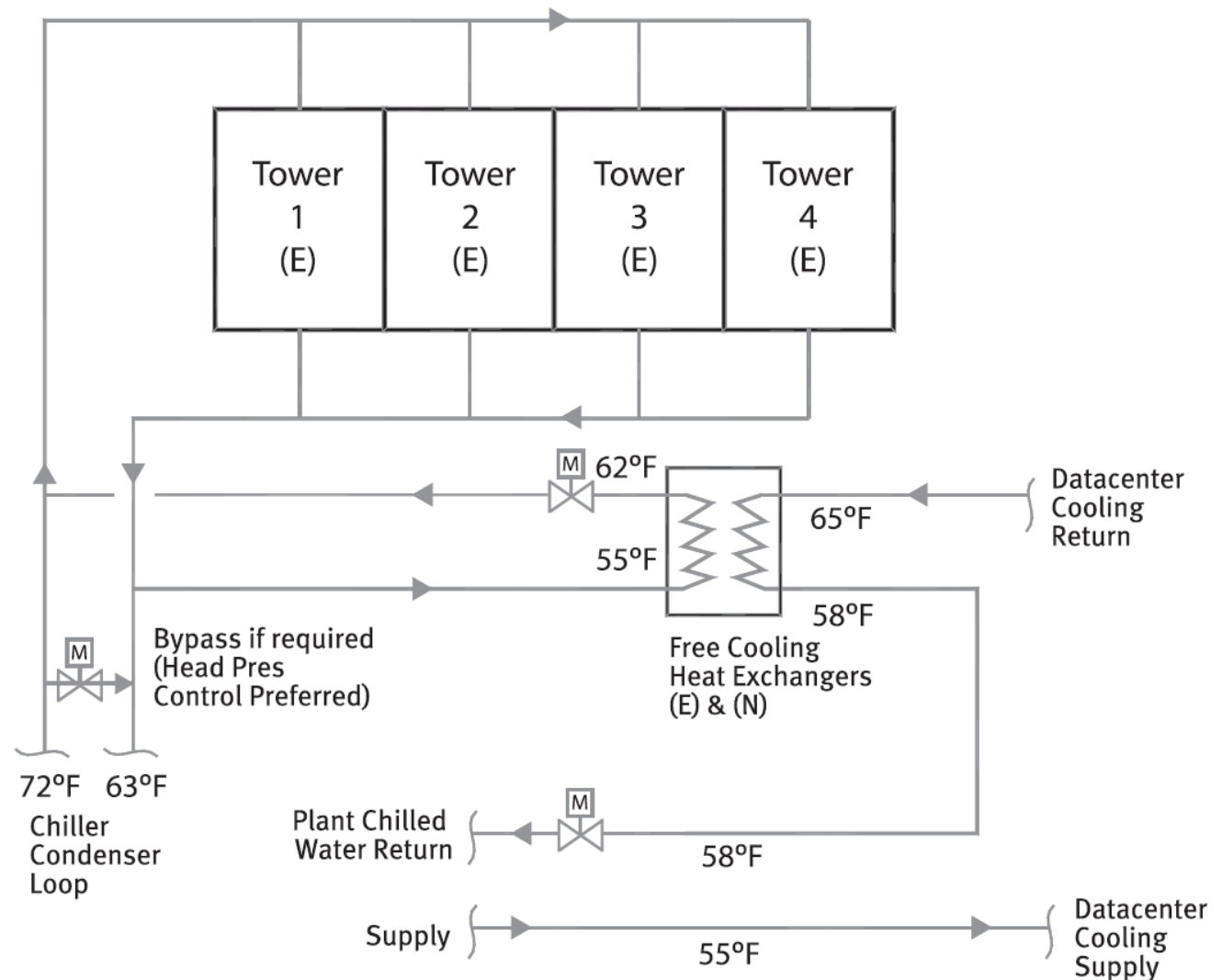
Three - Well Suited For 24 hr Load

Facility B Data Center Chiller 4 Power, Load and Efficiency - Oct 5 and 6



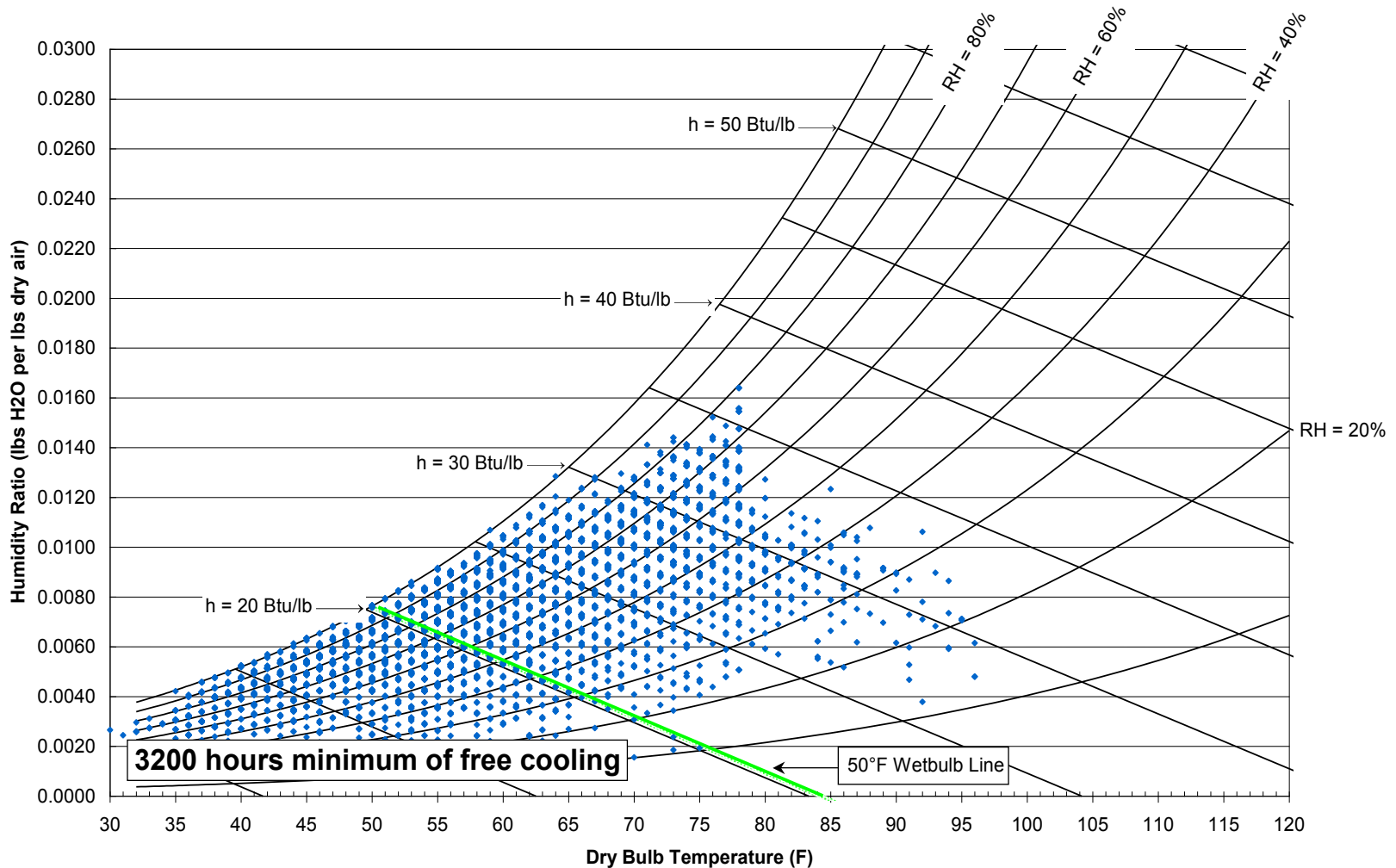


In Series with Chiller, Free Cooling Can Improve Reliability





Free Cooling





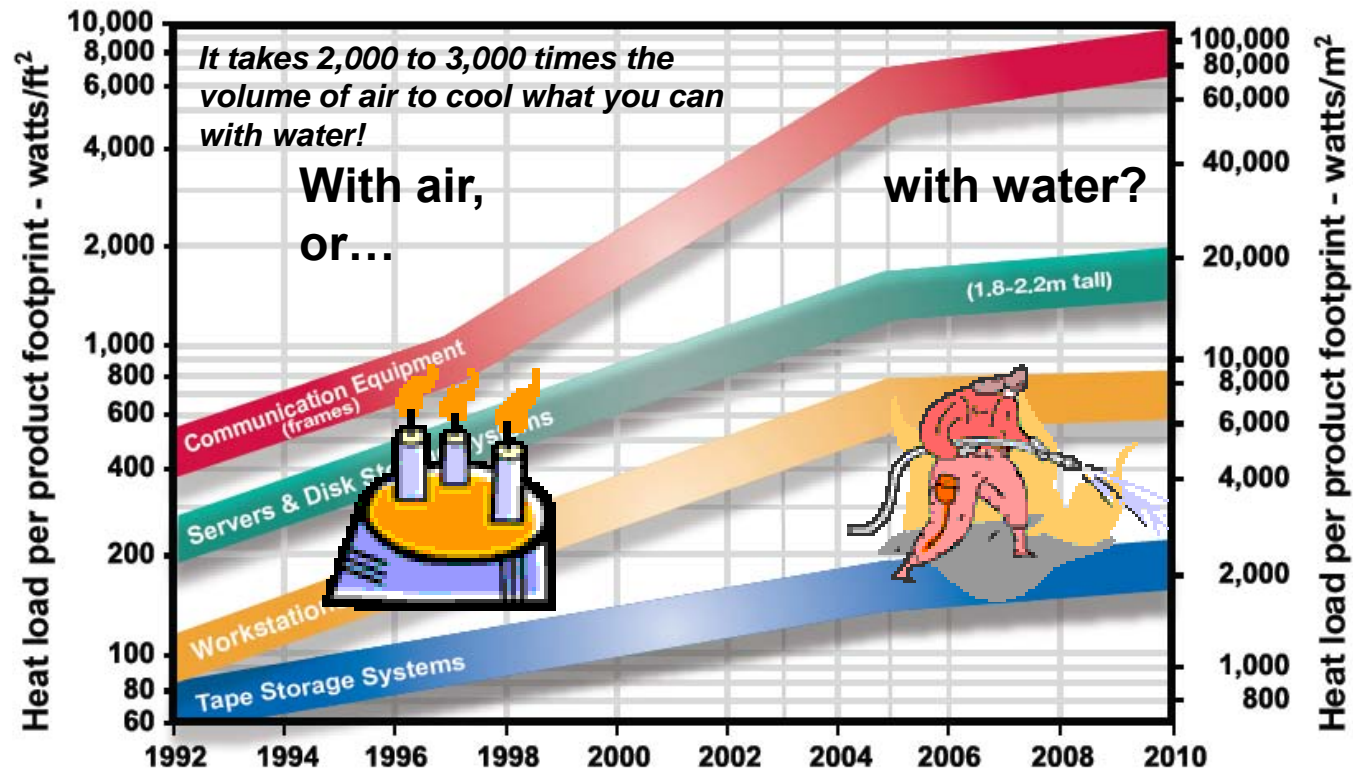
Conventional Cooling vs. Liquid Cooling

1000 kW data center load with free cooling

	Cooling Towers and Pumps	Chiller	Chilled Water Pumps	Fans	Other	Total Power	% SAVINGS
Traditional System - 45 Deg F Chilled Water	70	500	50	150	n/a	770	N/A
Liquid Cooled with Fans in the Rack - 55 Deg F Chilled Water	70	255	50	100	n/a	475	38%
Liquid Cooled without fans in the rack - 55 Deg F Chilled Water	70	255	50	0	n/a	375	51%
Liquid Cooled directly couple with CPU - 70 to 80 deg F Chilled Water	70	0	50	0	Room A/C - 150	270	65%



How do you effectively fight a fire?



Year of First Product Announcement / Year of First Product Shipment



Take Aways

- Liquid has greater heat removal capacity
- Pumps are more efficient than fans
- Coupling heat removal to the source eliminates mixing
- Commercial liquid solutions are available
- Water-side free cooling provides cooling with reduced chiller operation for much of the year in California